

QU'APPELLE FISHING LAKES

NUTRIENT LOADING STUDY, 1982

REPORT #3

(INTERIM)

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1.0 SUMMARY

It is intended that the data obtained during the period 1979-85 will provide an accurate estimate of nutrient loads; as well as, an estimate of any trend in nutrient loads and quality at two sampling sites in the Qu'Appelle River Basin. This interim report is a progress report for 1982, the third year of the study.

Three day composite samples were collected throughout 1982 from the Qu'Appelle River at the site above Pasqua Lake. At the site below Katepwa Lake, grab samples were collected at three day intervals. In this manner, 122 samples were collected from each site. Eight cross-section and eight seasonal grab sample sets were also collected at each site to determine correction factors for the nutrient load calculations. The analytical results from this sampling program and the Water Survey of Canada flow data were used to determine nutrient loads into and out of the Qu'Appelle Fishing Lakes. Changes in the relative concentrations of nutrient species and their concentrations were also examined.

Based on these data, an estimated 34.42 ± 1.99 tonnes of phosphorus were transported out of the Fishing Lake and 256.9 ± 9.09 tonnes of nitrogen were retained in the Fishing Lakes during 1982. These net loads are based on estimated inflows and outflows of 59.66 ± 1.01 and 94.08 ± 0.98 tonnes of phosphorus and 469.9 ± 5.68 and 213.0 ± 3.41 tonnes of nitrogen, respectively.

There were two major changes in the loading patterns in 1982 compared to 1980 and 1981. First, the substantial increase in phosphorus load leaving the Fishing Lakes which resulted in a net loss of 34.4 tonnes of phosphorus. Second, the winter months were of decreased significance in terms of the annual nutrient load. Both of these changes can probably be largely attributed to the increased flow during 1982.

As in previous years, there was a substantial difference between the amount of particulate phosphorus entering and leaving the Fishing Lakes. During 1982, particulate phosphorus represented about 55% of the phosphorus load into the Fishing Lakes and about 16% of the phosphorus load out of the lakes. This trend was most apparent during the open-water season.

An accurate estimate and characterization of the nutrient loads during low flow regimes, based on two consecutive years 1980 and 1981 now appears feasible. Alternatively, 1982 has provided information on a moderate flow years. The difference in nutrient loading patterns between the three years of monitoring show that under various flow regimes the loading patterns are different. Therefore, it is necessary to continue monitoring above and below the Fishing Lakes to obtain more data under various flow conditions if accurate nutrient loads into the Fishing Lakes are to be determined and any trends that may exist identified.

The operational cost of the Qu'Appelle Fishing Lakes nutrient study was \$64,400 and 1.0 person years in 1982.

2.0 INTRODUCTION

In 1980, Water Quality Branch, Environment Canada, undertook a long term study to examine trends in the nutrient loading to and from the Qu'Appelle Fishing Lakes via the Qu'Appelle River (See Figure 1). The study objectives were as follows:

- (1) conduct intensive sampling of the Qu'Appelle River to accurately determine nutrient loading into and out of the Fishing Lakes.
- (2) to estimate the effect of the City of Regina's tertiary treatment plant on the phosphorus loading to the Fishing Lakes. Effluent from the City of Moose Jaw will also be reviewed in this same context.
- (3) to estimate trends in the nutrient quality, loading and productivity of the Qu'Appelle River above Pasqua Lake and below the Fishing Lakes.

The results of that portion of the study conducted in 1980 and 1981 were reported by Environment Canada (1982 a, b). This interim report presents the results from the 1982 intensive sampling program complete with computational estimates of the nutrients loads into and out of the Fishing Lakes. Limited effort has been placed on interpreting the results presented in this report. A more complete

interpretation of all the results from this study will be carried out after completion of the sampling program and will be included in the final report.

3.0 METHODS

The sampling locations (Figure 1) and the methods used during 1982; including, sampling, analytical and statistical methods, were unchanged from those used during previous years. These were reported in the 1980 interim report (Environment Canada, 1982 a).

Due to continuing problems encountered at the site below Katepwa Lake, the use of a composite sampler was discontinued at this site in 1982. Instead, grab samples were collected every third day. At the site above Pasqua Lake, the composite sampler was used throughout the year. On 23 occasions when the sampler or pump malfunctioned, grab samples were substituted.

It should be noted that the flow data used in this report are preliminary. Subsequent changes to these data could cause changes in the loading computations presented in this report.

4.0 RESULTS AND DISCUSSION

4.1 Flow

The flows based on means for the three day sampling periods, calculated from Water Survey of Canada mean daily flow results for the two sampling sites, are shown in Figures 2 and 3.

The flow in the Qu'Appelle River during 1982 was much higher than in the previous years of this study. At the site above Pasqua Lake, the spring peak occurred between April 15 and May 25 with the maximum daily discharge ($50.9 \text{ m}^3/\text{s}$) occurring on April 27. After the spring peak the flow leveled off in early June to about $3.0 \text{ m}^3/\text{s}$ and remained at that level until the end of September. During October the flow increased due to lake draw-down with flows as high as $8.0 \text{ m}^3/\text{s}$ occurring in early November. These increased flows continued through the end of the year. The total discharge during 1982 at the site above Pasqua Lake was 202,000 DAM^3 , approximately twice the total discharge of the two previous years. The total discharge in 1982 was approximately equal to the mean annual discharge for this site over the period 1968 to 1982 (Environment Canada 1980). At the site below Katepwa Lake, the spring peak occurred between April 14 and June 11 with the maximum daily discharge ($33.6 \text{ m}^3/\text{s}$) occurring on May 10. The summer flow fluctuated between 1.0 and $4.0 \text{ m}^3/\text{s}$ except for about a week in early July when the flow

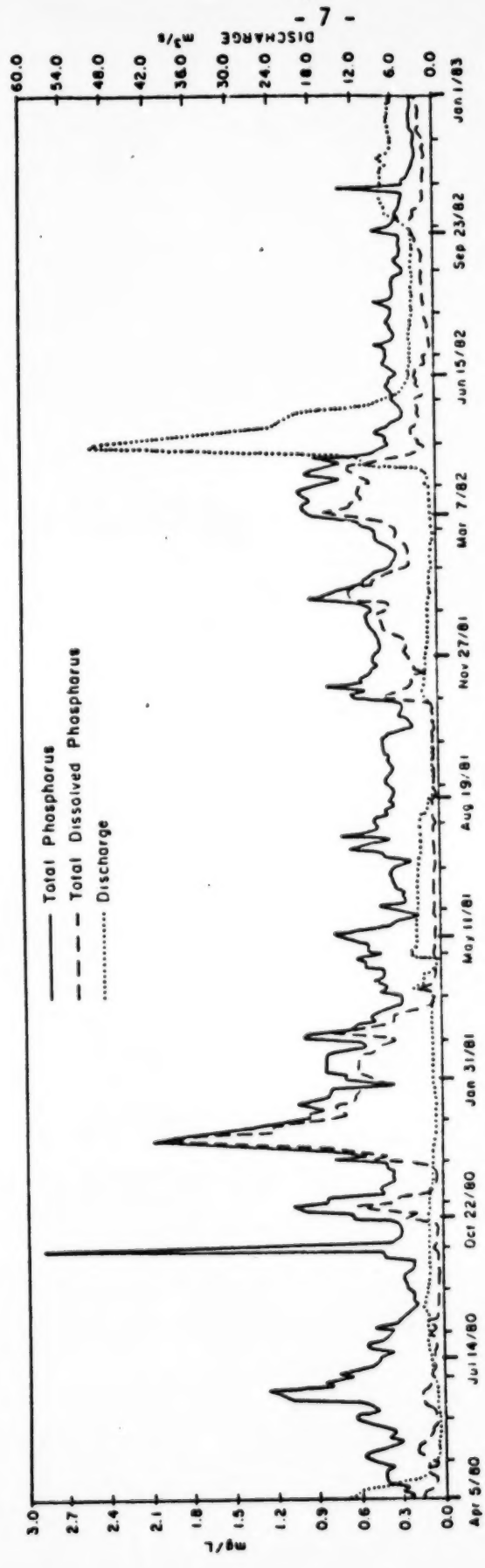


Figure 2. Discharge and Phosphorus Concentration in the Qu'Appelle River above Pasqua Lake, April 1980 to December 1982.

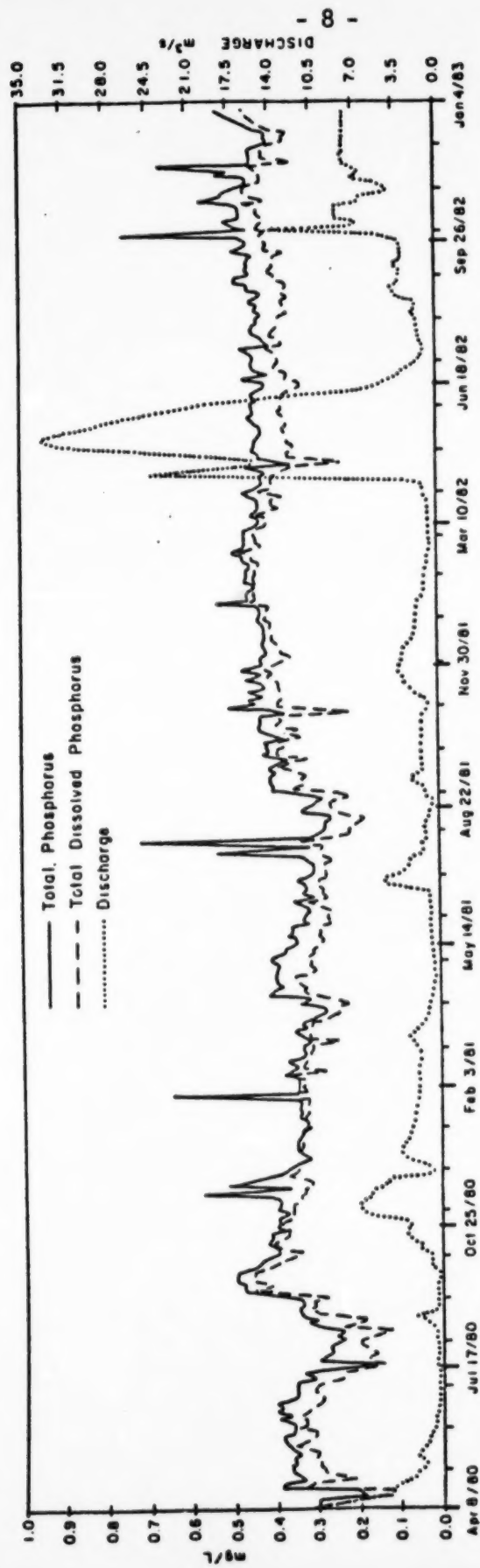


Figure 3. Discharge and Phosphorus Concentration in the Qu'Appelle River below Katepwa Lake, April 1980 to December 1982.

was below $1.0 \text{ m}^3/\text{s}$. On October 5 and 6 the flow increased to 20.2 and $16.0 \text{ m}^3/\text{s}$ respectively with the initiation of lake draw-down. After this short peak the flow declined and was between 6.0 and $8.5 \text{ m}^3/\text{s}$ through the end of 1982.

In summary the total discharge from Katepwa Lake was $212,000 \text{ DAM}^3$ during 1982 which is more than twice the combined discharge ($99,800 \text{ DAM}^3$) from the two previous years of the study. The 1982 discharge is less than the mean annual discharge ($257,000 \text{ DAM}^3$) for the period 1968 to 1982 (Environment Canada 1980).

4.2 Nutrient Concentration

A total of 122 composite or grab samples were collected at each of the two study sites during 1982. The temporal variability of phosphorus and nitrogen concentrations during this period and the two previous years is shown in Figures 2 to 5. The mean three day flows for the study period 1980-83 are also shown.

During 1982, the total phosphorus concentration at the site above Pasqua Lake (Figure 2) followed a somewhat different temporal pattern to that seen in previous years. Total phosphorus did not reach the high January concentration observed in the previous year. Following a brief decline in concentration, TP rose, again in late February to concentrations comparable with 1981. During the spring freshet, for which there are no

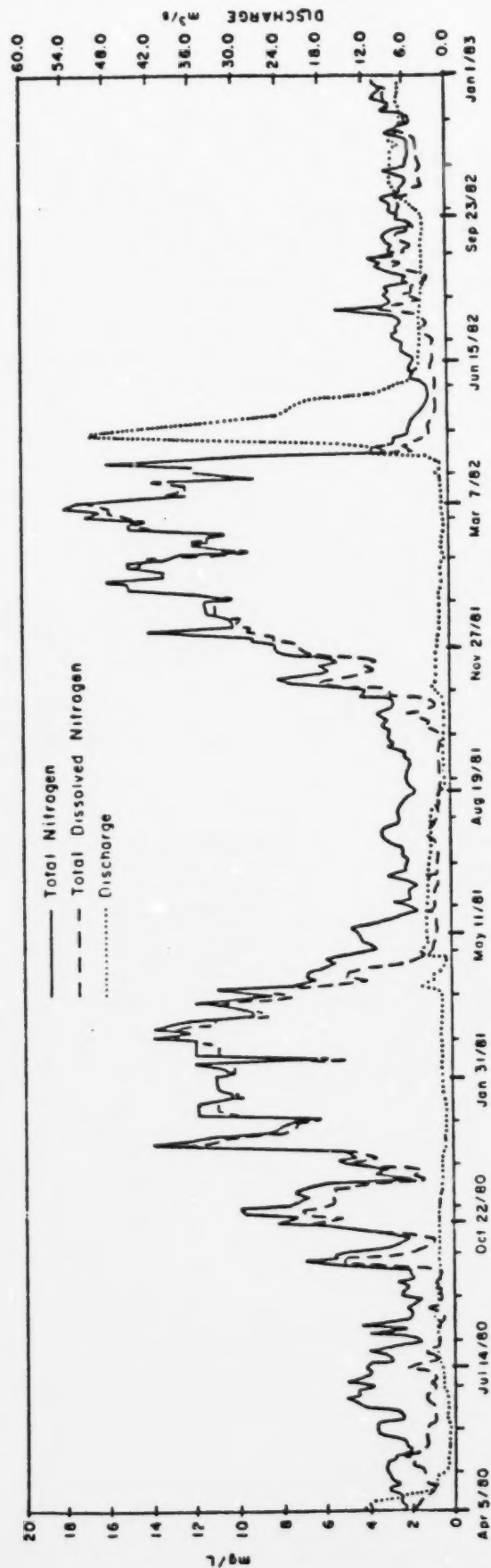


Figure 4. Discharge and Nitrogen Concentration in the Qu'Appelle River above Pasqua Lake, April 1980 to December 1982.

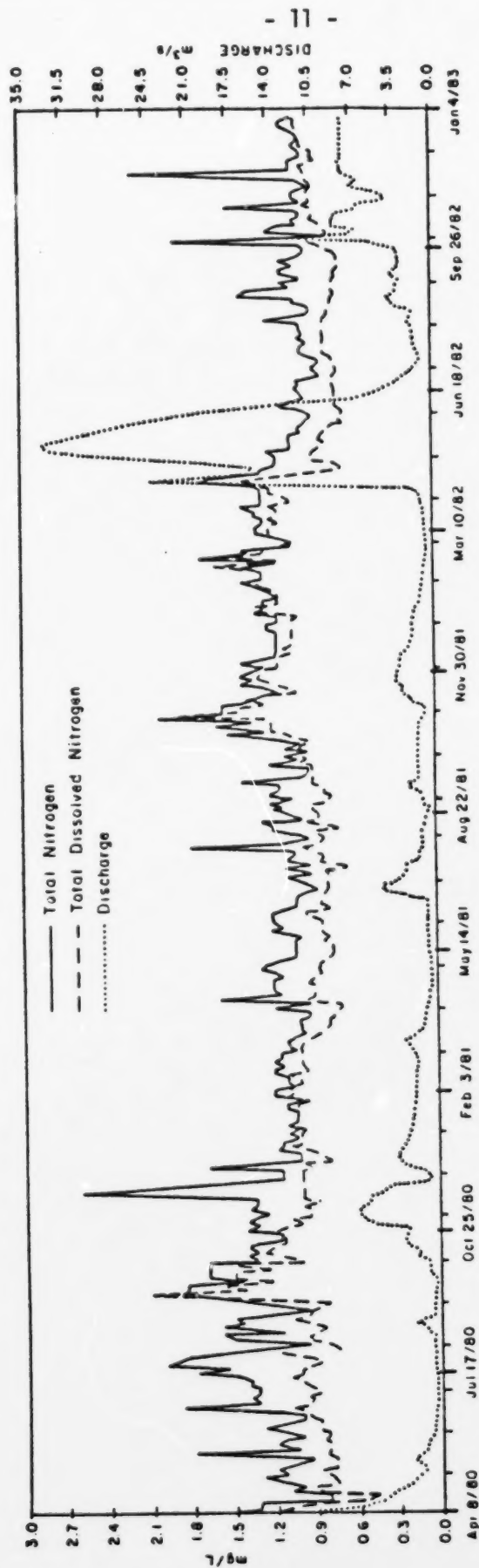


Figure 5. Discharge and Nitrogen Concentration in the Qu'Appelle River below Katepwa Lake, April 1980 to December 1982.

comparable data as yet, the total phosphorus concentration decreased substantially to levels comparable to those found in April 1980 and 1981. After this spring decline the levels remained relatively constant at 0.25 mg/L until freeze-up, not reflecting the fluctuation in total phosphorus seen in previous summers. At freeze-up, the total phosphorus concentration decreased to about 0.15 mg/L and remained at that concentration to the end of the year. This was a significant divergence from previous years when the phosphorus concentration increased substantially at freeze-up. This total phosphorus decrease in 1982 was probably a result of the high flow (about 8.0 m³/s) which was maintained after freeze-up to draw-down the upstream lakes.

As in previous years, dissolved phosphorus at the site above Pasqua Lake represents a small portion of the total phosphorus during the open water period and the major portion during periods of ice cover. However, the portion of dissolved phosphorus during the early summer (end of June) and again in September of 1982, was considerably greater (about 50% of TP) than that seen in previous years (about 10% of TP).

At the site below Katepwa Lake, total phosphorus concentrations varied within a much narrower range than at the site above Pasqua Lake. However during 1982, the range of total phosphorus concentrations was more constant (between 0.40 and 0.55 mg/L) but higher than in previous years. These high phosphorus levels began in early September, 1981,

and continued throughout 1982. As in previous years, dissolved phosphorus made up the major portion (about 80%) of total phosphorus.

In 1982, total nitrogen concentrations above Pasqua Lake (Figure 4) followed a pattern similar to that seen in previous years, with the highest concentrations (10-20 mg/L) occurring during the period of ice cover. The 1982 summer total nitrogen concentrations were similar to those found in preceding years and ranged between 2 and 4 mg/LN. The dissolved nitrogen represented the majority of the total nitrogen during periods of ice cover, and only a small portion during open-water periods. As with dissolved phosphorus, dissolved nitrogen presented a greater portion of total nitrogen in 1982 than in previous years.

Total nitrogen concentration below Katepwa Lake (Figure 5) varied considerably during 1982. However, a general pattern was apparent. Total nitrogen fluctuated around 1.2 mg/L during the winter months then decreased during the spring to about 0.80 mg/L by the end of June. Through the rest of the year, the total nitrogen concentration gradually increased reaching a level of 1.0 mg/L by the end of the year. Dissolved nitrogen, which represented the major portion of the total nitrogen, followed the same general pattern except the spring decline was more rapid. This general pattern was different from previous years when only a slight spring decline, followed by a rapid return to a relatively constant level was observed.

4.3 Nutrient Loading

The total phosphorus load entering Pasqua Lake from the Qu'Appelle River in 1982 was estimated to be 59.66 $\pm$ 1.01 tonnes. The dissolved portion of this total phosphorus load was 26.89 $\pm$ 0.48 tonnes or 45 percent of the total phosphorus load. At the sampling location below Katepwa Lake, the total phosphorus load was 94.08 $\pm$ 0.98 tonnes, of which 78.47 $\pm$ 2.03 tonnes or 84 percent was dissolved phosphorus. Evidently during 1982 a net total phosphorus transport out of the Fishing Lakes of 34.42 $\pm$ 1.99 tonnes occurred. This net negative load is substantially different from the net positive load to the lakes of 10.68 $\pm$ 0.89 tonnes determined for the 21 month period April 1980 to December 1981 (Environment Canada, 1982a, b).

A monthly breakdown of the phosphorus loads at the two sampling locations is presented in Table 1. The monthly total phosphorus load to Pasqua Lake was highest in April (17.89 $\pm$ 0.74 tonnes) due to the higher flow during that month. February had the lowest monthly phosphorus load (0.56 $\pm$ 0.01 tonnes) due to the low flow at the time and decline in phosphorus concentration. The monthly total phosphorus loads, passing the station below Katepwa Lake, were highest in May (34.13 $\pm$ 0.55 tonnes) reflecting the higher flow during this month. February had the lowest monthly phosphorus load (0.61 $\pm$ 0.02 tonnes). The months of May, June, October, November and December all demonstrated significant net negative loads to the Fishing Lakes with the output load

Table 1 Monthly Phosphorus and Nitrogen Loads (Tonnes) Into and Out of the Fishing Lake, 1982.

Date	Qu'Appelle River Above Pasqua Lake				Qu'Appelle River Below Katepwa Lake			
	Total Phosphorus	Dissolved Phosphorus	Total Nitrogen	Dissolved Nitrogen	Total Phosphorus	Dissolved Phosphorus	Total Nitrogen	Dissolved Nitrogen
Dec. 30 to Jan. 31	1.58 +/- 0.04	1.27 +/- 0.03	39.77 +/- 1.48	35.80 +/- 1.07	1.48 +/- 0.02	1.50 +/- 0.52	4.27 +/- 0.53	3.98 +/- 0.16
Jan. 31 to Feb. 27	0.56 +/- 0.01	0.38 +/- 0.02	18.81 +/- 0.96	17.42 +/- 0.72	0.61 +/- 0.02	0.61 +/- 0.03	1.87 +/- 0.06	1.89 +/- 0.06
Feb. 27 to Apr. 1	2.91 +/- 0.05	1.76 +/- 0.08	38.45 +/- 2.33	35.86 +/- 1.52	0.86 +/- 0.01	0.86 +/- 0.03	2.64 +/- 0.06	2.42 +/- 0.05
Apr. 1 to May 1	17.89 +/- 0.74	7.36 +/- 0.31	105.5 +/- 3.48	64.59 +/- 1.43	13.14 +/- 0.27	10.30 +/- 0.91	39.8 +/- 1.42	27.64 +/- 1.73
May 1 to May 31	16.39 +/- 0.65	8.13 +/- 0.33	64.84 +/- 2.28	35.20 +/- 0.87	34.13 +/- 0.55	26.88 +/- 1.60	75.53 +/- 2.25	57.27 +/- 2.18
May 31 to June 30	2.82 +/- 0.07	1.07 +/- 0.03	14.35 +/- 0.48	6.13 +/- 0.12	10.57 +/- 0.21	8.61 +/- 0.53	22.9 +/- 0.79	16.36 +/- 0.76
June 30 to July 30	2.94 +/- 0.06	0.44 +/- 0.01	23.47 +/- 0.73	12.36 +/- 0.30	1.47 +/- 0.02	1.29 +/- 0.04	2.89 +/- 0.08	2.40 +/- 0.07
July 30 to Sept. 1	2.45 +/- 0.07	0.77 +/- 0.03	22.95 +/- 0.50	15.21 +/- 0.46	3.01 +/- 0.05	2.52 +/- 0.13	7.05 +/- 0.23	4.61 +/- 0.09
Sept. 1 to Oct. 1	2.14 +/- 0.08	1.27 +/- 0.06	20.63 +/- 0.40	16.90 +/- 0.47	3.47 +/- 0.06	3.00 +/- 0.12	7.42 +/- 0.21	5.32 +/- 0.11
Oct. 1 to Oct. 31	4.74 +/- 0.12	1.59 +/- 0.08	42.47 +/- 1.77	27.73 +/- 0.64	10.00 +/- 0.19	8.73 +/- 0.26	18.68 +/- 0.97	16.76 +/- 0.34
Oct. 31 to Nov. 30	2.46 +/- 0.10	1.18 +/- 0.05	32.65 +/- 0.86	29.32 +/- 0.61	6.89 +/- 0.12	6.65 +/- 0.14	10.30 +/- 1.55	14.70 +/- 0.29
Nov. 30 to Dec. 30	2.74 +/- 0.11	1.64 +/- 0.05	44.77 +/- 1.16	44.70 +/- 0.94	8.36 +/- 0.13	7.42 +/- 0.21	19.25 +/- 0.47	19.06 +/- 0.36

of total phosphorus ranging from 2 to 4 times greater than the input load. All months, except February, demonstrated a net negative load of dissolved phosphorus.

The total nitrogen load in the Qu'Appelle River above Pasqua Lake in 1982 was 469.9 +/- 5.68 tonnes of which 342.4 +/- 3.00 tonnes or 73 percent was dissolved nitrogen. Below Katepwa Lake, the total nitrogen load in 1982 was 213.0 +/- 3.41 tonnes and the dissolved portion was 172.7 +/- 2.68 tonnes or 81 percent of the total. These data indicate a net influx in the order of 256.9 +/- 9.09 tonnes of nitrogen to the Fishing Lakes, a load comparable to the 241.0 +/- 8.12 tonnes net nitrogen during 1981 (Environment Canada, 1982b).

A monthly breakdown of the nitrogen loads at the two sampling locations is presented in Table 1. Monthly total nitrogen loads above Pasqua Lake were highest in April (105.5 +/- 3.48 tonnes) and lowest in June (14.35 +/- 0.48 tonnes). As in 1981, the winter months contributed a large portion (51 percent) of the total nitrogen load at this site. Below Katepwa Lake, the monthly nitrogen loads were highest in May (75.53 +/- 2.25 tonnes) and lowest in February loads (1.87 +/- 0.06 tonnes).

5.0 PERSPECTIVE

It is apparent after nearly three years of sampling, that the nutrient loads into and out of the Fishing Lakes vary considerably. Noteworthy, is the net negative load to the Fishing Lakes for total and dissolved phosphorus during 1982. Seasonal variations in net loads can also be anticipated. This variability appears to be primarily in response to variations in flow regimes in combination with limnologic factors affecting in-lake storage and release of nutrients. However, the available data for a period of less than three years, is just beginning to describe this variability. Any efforts to explain the processes determining nutrient load variability will require continued monitoring at the two sites.

Attainment of the objectives of the study, specifically, quantification of loads, estimating the effect of enhanced municipal sewage treatment and estimating nutrient loading and lake productivity trends will require a greater understanding of load responses to hydrophysical factors. Additionally, the importance of in-lake nutrient storage and release factors is critical to achieving these objectives yet there remains no complementary in-lake nutrient and productivity data. Curtailment of the monitoring program therefore seriously limits the effectiveness of the monitoring activities conducted to date. Nevertheless, further monitoring activities should only be developed following a thorough review of the existing data and the development of a system specific

framework for data collection and synthesis. This will be a major objective of the summary and evaluation report under preparation by the Branch.

6.0 RESOURCES 1981/82

Person Years

1.0

Salary (\$000)	30.0
Operational Expenses (\$000)	
Field	25.0
Laboratory	9.4
Capital (\$000)	0.0
Total Cost (\$000)	64.4

Recovered from the Qu'Appelle Implementation Office (\$000)
35.0

REFERENCES

- Environment Canada, 1980. Historical Streamflow Summary Saskatchewan to 1979. Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa, Ontario
- Environment Canada, 1982a. Qu'Appelle Fishing Lakes Nutrient Loading Study, 1980. Report #1 (Interim). Water Quality Branch, Western and Northern Region, Regina, Saskatchewan.
- Environment Canada, 1982b. Qu'Appelle Fishing Lakes Nutrient Loading Study, 1981, Report #2 (Interim). Water Quality Branch, Western and Northern Region, Regina, Saskatchewan.